Environmentally Preferred Advanced Generation's

California Advanced Combined Heat and Power Collaborative

Program Goals and Targets

DRAFT

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I. PURPOSE

The Environmentally Preferred Advanced Generation (EPAG) area of the California Energy Commission's Public Interest Energy Research Program is conducting this *Advanced CHP Collaborative* to improve the economics of CHP in California. The CHP program will focus on system level technologies to increase overall utilization efficiencies, reduce installed costs and maximize value to the California end users. Advancements to and commercialization of CHP system technologies that reduce cost, increase overall utilization efficiency and/or add other value will accelerate the implementation of CHP in California. This program will complement ongoing Energy Commission Distributed Generation R&D on engines, turbines, micro-turbines, fuel cells and utility interface technologies.

As part of this *Advanced CHP Collaborative*, EPAG is planning to issue a solicitation in late summer of this year directed at overcoming technology barriers to Combined Heat and Power (CHP) Systems. The purpose of this document is to set forth the solicitation's draft CHP targets and illicit public comment in order to improve them. Public comment can be made either in person at one of EPAG's planned workshops or via e-mail. The first workshop will be held on Tuesday, May 13, 2003, at the Radisson Hotel in Newport Beach, California, from 8:00 to 12:00. The second workshop will be held on Friday, May 16, 2003, at the Lowes Coronado Bay Resort in San Diego, California from 11:00 to 3:00. Both workshops are free and open to the public. To find out more about these workshops please visit www.energy.ca.gov/contracts or call Allan Ward at the California Energy Commission at (916) 651-6196. To comment via e-mail, please send information to alward@energy.state.ca.us. The comment period will last until May 27, 2003. Revisions to this document will be made based upon the comments received, and then the final version will be posted on this website and incorporated into the planned solicitation.

Advanced CHP technologies include factory integration of absorption chillers and other ancillary equipment for targeted applications, more cost effective thermally activated cooling technology, and value-added features such as grid communication interfaces and uninterruptible power supplies. Value-added features should provide an accretive revenue stream or displace the need for traditional equipment, improving the economics of a CHP system designed only to displace electric and gas purchases.

It is recognized that work in this area is already ongoing by various stakeholders including DOE, packagers, system integrators and others. The Energy Commission desires to build upon this work to tailor applicability and to accelerate commercial use in the California market. Accordingly, cost sharing and collaboration are important aspects of this planned program.

Please note that the EPAG workshops mentioned above are being held in conjunction with two conferences: the Federal Energy Management Program CHP conference in Newport Beach, California on May 13-15, and the National Association of Energy Service Companies conference in San Diego, California on May 14-16. For more information on the Federal Energy Management Program CHP conference, please visit www.energetics.com/femp/la.html. For more information on the National Association of Energy Service Companies conference, please visit www.naesco.org/conference.htm.

II. BACKGROUND

Combined heat and power (CHP) is the sequential production of electricity and recovery of waste heat that has many benefits for energy-conscious policy. CHP technologies include reciprocating engines, combustion turbines, steam turbines and more recently micro-turbines, Stirling engines and fuel cells. Power generation systems create large amounts of heat in the process of converting fuel into electricity. Typically over two-thirds of the energy content of the input fuel is converted to heat and wasted. As an alternative, an end-user with significant thermal and power needs can generate both in a single combined heat and power (CHP) system.

A. CHP Benefits

CHP systems typically have overall efficiencies of 60-80% as compared to power-only systems that average less than 40% efficiency. The resulting benefits of deploying CHP systems can include:

- Energy cost savings as compared to supplying heat and power loads separately
- Power Quality and reliability improvements associated with distributed generation
- T&D support associated with distributed generation
- Reduced air emissions as compared with supplying heat and power loads separately
- Natural gas conservation when the alternative electric power supply is fueled with natural gas.

B. Existing CHP in California

There are approximately 700 CHP systems installed in California with an electrical capacity of approximately 6,500 MW. Although the number of CHP installations is roughly distributed equally among commercial, industrial and institutional sectors, the industrial sector dominates overall CHP capacity. Other characteristics of the existing population of CHP systems in the state include:

Fuel Type	· 90% use natural gas · Coal, waste fuels and wood are minor contributors
Installed Base	· 5,700 MW (industrial) · 320 MW (commercial) · 480 MW (institutional)
System Size	· 25 MW (avg. industrial) · 1.3 MW (avg. commercial) · 2.4 MW (avg. institutional)

Technologies	·	Reciprocating engines (66% of sites)
	·	Combustion turbines (85% of installed capacity)
	·	Fuel cells and micro-turbines (minor)

C. Decline of CHP in California

Growth of CHP in California dramatically increased with the passage of the Public Utility Regulatory Policies Act of 1978 (PURPA), enacted during the Carter Administration as a reaction to the energy crisis caused by the middle east oil embargo. Before its passage, there were less than 12 CHP systems operating in the state. Over the next ten years, more than 380 additional systems were installed. The decade from 1988 to 1997 added over 270 more systems. Annual growth in CHP capacity went from less than 1% in the 1970s to 27% in the 1980s. However, by the 1990s, the annual growth rate had slowed to just over 4%. In 1998, after nearly sixteen years of double-digit plant additions, only one CHP plant was added.

The CHP market decline in California resulted from lower avoided costs for power sold to the grid and increasing utility resistance. Utility resistance came in the form of high standby rates, demand charges and a costly interconnection process. More stringent state environmental requirements also helped to depress the market for all on-site generation in the 1990s.

D. Remaining Technical CHP Market Potential in California

Substantial CHP opportunities still exist in California. **Tables 1 and 2** show the estimated remaining potential for CHP in California by major economic sectors.[1]

Table 1. Remaining CHP Technical Potential in California's Industrial Sectors

Industry	CHP Technical Potential (MW)
Petroleum Industry	2,100
Food Processing	1,400
Pulp and Paper	1,000
Chemicals	700
Lumber and Wood	500
Other	800
Total	**6,500**

[1] *Market Assessment for Combined Heat and Power in the State of California*, California Energy Commission, prepared by Onsite Sycom Energy Corporation, Carlsbad, California, 1999.

Table 2. Remaining CHP Technical Potential in California's C&I Sectors

Sector	CHP Technical Potential (MW)
Education	2,300
Restaurants	1,100
Hotels and Lodging	900
Apartments	700
Health Care	300
Other	300
Total	**5,600**

While there are still some traditional CHP applications (i.e. heavy steam users – refining, chemicals, Pulp & Paper) that haven't yet incorporated CHP, the vast majority of California's remaining potential are in the commercial and light industrial sectors. Commercial and light industrial heat loads will not be the large steady steam loads that have historically been linked to CHP plants. Cost effective integration of thermally activated cooling will often be key to obtaining the operating benefits necessary for cost effective CHP projects in the commercial and light industrial sectors. Another unique characteristic of California are its stringent environmental requirements, which may add cost and complexity to a CHP project.

E. Critical Market Factors

The extent to which this potential CHP market that can realistically be penetrated is difficult to estimate. Policies and regulations critical to CHP are still being formulated. How these rules are shaped and implemented will have significant impact on customer and utility interest in CHP. Critical factors for the future development of this market can be summarized as follows:

- CHP performance and cost attributes that can provide net power service below the California market clearing price.
- Technology Advancement – Cost-effective environmental compliance techniques; Higher overall utilization efficiencies; lower cost heat driven cooling systems; application benchmarking designs
- Government Policies – Recognition of societal and economic benefits; Regulatory treatment paralleling that for energy efficiency and renewables; Stable and long-term government commitment to enable multi-year investment decisions by users; Simplified and less costly permitting and monitoring procedures
- Utility Attitudes – Recognition that CHP provides Capacity/T&D support; Fair backup & standby rates; User friendly interconnect guidelines
- User Awareness – Public outreach for CHP; Case studies; Stable government support.

F. CHP Technology Needs

The gap between technology available today and the application needs in the commercial, institutional, and industrial sectors is a significant barrier. The current needs of those wanting to promote or use CHP are as follows:

- Less costly, complex, and maintenance intensive CHP, heat recovery, and thermally activated technologies.
- Cost-effective, efficient, reliable and ultra-low emission prime movers
- A single source for integrated equipment (which is likely to reduce acquisition and installation costs); currently, a CHP package is made up of separate products from a variety of manufacturers.
- A better understanding of application energy use characteristics and in particular the coincidence (or lack thereof) of thermal and electric needs
- Economically recovering and using energy from low temperature heat sources.
- Less costly and cumbersome integration of existing CHP products with existing building systems such as rooftop units and air handling systems.
- Better awareness of CHP applications and benefits among customers, engineers, architects, regulators.
- Integrated controls for CHP system components

Other needs, although less technical in nature, that add knowledge and enable low cost design solutions, include:

- User friendly design tools
- Quantification of ancillary services associated with CHP such as reliability and power quality to both sides of the meter.

Developing more effective CHP systems that overcome these barriers (excluding prime mover specific needs) is the primary focus of the proposed solicitation.

III. CALIFORNIA PIER CHP COLLABORATIVE PLAN

EPAG plans to address the CHP technology needs listed above through its R&D solicitation. The program will have near-term and long-term goals. The near-term goal is to increase the use of CHP in California by overcoming technological barriers. Longer-term goals are to bring into economic reach a large portion of the remaining CHP potential in California. EPAG plans to release this solicitation in late summer of this year. The estimated funding for this RFP is 6 million dollars. At this time, EPAG anticipates funding 2 - 6 projects at a level up to 3 million dollars each. Following the solicitation, EPAG will reassess its CHP activities in about a year and plan for additional programs if warranted.

Beyond the solicitation, EPAG is interested in other collaborative efforts that will lead to increased use of CHP in California. For example, EPAG recently facilitated applications to a DOE solicitation for Regional CHP Applications Centers.

A. Scope of CHP Solicitation

The scope of the planned solicitation will be open to wide spectrum of research, development and demonstration projects directed at commercial, institutional, and/or industrial market segments of sufficient size to warrant PIER Program funding support. The technical focus of the planned solicitation is as follows:

- Component Integration Optimizing Overall Energy Utilization – Current CHP systems involve the custom integration of disparate pieces (prime mover, generator, controls, heat recovery, cooling, dehumidification, other thermal processes). Integration of these functions and hardware into more efficient and less costly prepackaged systems is an important development goal. This area can also include innovative demonstration projects that offer the prospect of being reproduced at multiple sites.
- Cooling, heating, dehumidification – absorption cooling equipment optimized to lower temperature heat sources, development of air-cooled cycles, integration of multiple uses, e.g., absorption and desiccant systems, improved efficiency systems, lower cost and maintenance, demonstration of new cooling/dehumidification technologies
- Application matching, control systems, and diagnostics – This area may include software tools to design and optimize CHP systems to applications, software and hardware to provide effective system control including economic dispatch of competing thermal applications, and operation and maintenance diagnostics and to create standard designs (benchmarking) for common applications.
- Heat Transfer and Heat Storage – heat exchangers, optimization of collection and use of multiple heat sources and temperatures, decoupling of supply and use through storage, integration with prime mover package designs, direct use of prime mover exhaust.
- Premium Power – CHP integration in high power reliability applications can reduce capital costs, save energy costs, and enhance power reliability.
- Utility interface and control – Equally as important as matching the building thermal needs to the system is the need for CHP systems to interface with the utility to maximize benefits. Such strategies may include coordination of scheduled and forced outage maintenance, and the ability to override thermal load following operation.
- Prime Mover – improvement to fuel cells, engines, turbines and microturbines cost, efficiency, and emissions characteristics is the focus of other California Energy Commission research programs work and ***is not*** the focus of the CHP systems solicitation. However, improvements to enhance the quality or useability of heat from the prime mover would an acceptable part of an overall systems development and demonstration project.

The Energy Commission is open to the type of effort that best serves the proposed target market. Projects can include system technology research, integration/packaging, product development, supporting software/design tools and commercialization activities. Below are examples of possible projects that could be considered for this solicitation:

Category	*Possible Projects*
Integrated Energy Systems for Buildings	· CHP/HVAC integrated packages · Optimized absorption chiller design and integration (reduced cost and size, lower temperature heat utilization, increased COP, reduced maintenance) · Design Benchmarking and Outreach to standardize designs, component specifications and installation practices. · Ultra-simple installation requirements at site (hot and chilled water line connections, single integrated controls connection, single power connection, single fuel connection to package) · Utilization/integration of thermal storage to match building needs with system output · Heat recovery integrated with the prime mover and optimized for thermal technologies, e.g. application of multiple heat sources and temperatures from reciprocating engines · Demonstration of advanced cooling or dehumidification cycles that can be coupled with power generation equipment. · Air-cooled, cost effective, thermally activated cooling system. · User-friendly Applications and Design Software to enable cost optimized sizing and operating strategies. · Improved Absorber/DX Interface Technology · Low-cost Small CHP hot water interface module · System building interface controls package and operating system diagnostics
Industrial Process CHP	· Direct use of turbine exhaust (rather than a heat recovery steam generator) · Optimized steam or advanced bottoming cycles such as Organic Rankine Cycle · Low NOx Supplemental Firing Combustors for Gas Turbines · High Temperature Fluid Heating from power generation equipment thermal output. · Low temp absorber integration for process

	refrigeration applications
Enhanced Value Markets	· CHP integrated Premium Power/High Reliability Systems · CHP Operational Tracking for Resource Planning, demand side response valuation and Standby Tariff design · CHP specific Utility Interface for congestion management and maintenance scheduling

B. Objectives, Targets, and Stretch Goals

Development projects should target a meaningful market segment(s) and show significant improvement to the baseline systems, representing what could be installed today or that would naturally develop without EPAG funding. **Table 3** shows example project goals for both the near-term and the mid-to-long-term. The near-term (Less than 2 years to commercial introduction) proposals should target a 20% or more improvement in CHP cost-effectiveness from current levels for intended markets. Mid-term proposals (3 to 4 years to commercial introduction) should target a 30% or more improvement. Longer-term goals (10 years) are not listed in this document but proposers are encouraged to include appropriate stretch goals for 2014.

Specific goals and corresponding levels of improvement may vary by project and targeted application(s). The goals and targets illustrated below are intended as examples and should be adjusted to fit the particular size(s) proposed. Some of the goals and targets may not apply to some of the proposed concepts.

1. The proposed system technology should be sized for the targeted market segment.
2. The stretch goals should define a system that is economic in California in the near-term and should enable widespread implementation in the mid- to longer-term.
3. Viable technology paths and budget/business plans to reach the stated goals should be evident in the proposal.

The Energy Commission seeking to fund a balanced portfolio of projects:

- Near-term and mid-term projects with a slight emphasis on nearer-term
- Diversity of applications and technology.

Table 3. Example Project Targets and Stretch Goals

Ex. 1: Small Commercial CHP Package			
A complete CHP system skid mounted in a single package that includes prime mover, heat recovery, absorber, pumps, heat exchangers and switchgear that is designed for minimal engineering and installation labor. Near-term priorities are aimed primarily at cost reduction. Mid and longer term emphasis balances cost reduction with performance improvements. Proposals addressing system sizes of 60 to 500 kW are envisioned. However, performance parameters and targets need to be adjusted to fit the size.			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
size (kW)	100	100	100
Absorber size (tons)	25	28	35
Absorber COP	0.6	0.65	0.8
Package Cost ($/kW)	1500	1000	800
Installation Costs ($/kW)	1000	500	300
Emissions (CARB)	2003	2003	2007
Package Efficiency (HHV)	70%	75%	80%
Maintenance ($/kWh)	0.02	0.016	0.012
Availability	92%	94%	96%

Ex. 2: High Reliability System for Data Centers			
A CHP system that actively contributes to power reliability in premium power applications reducing dependence on and cost for conventional uninterruptible power supply (UPS) systems. The Baseline case is a conventional UPS system with redundant utility services, batteries, diesel gensets, and chillers. It does not include a CHP plant.			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
Raised Floor Area (ft^2)	80,000	80,000	80,000
Size (kW)	15,000	15,000	25,000
Reliability (# 9s)	5	6	6
Installed Cost ($/kW)	5300	4000	3400
Overall Efficiency (HHV)	N/A	70%	75%
Absorber COP	N/A	.65	1.0
Absorber Cost ($/ton)	N/A	300	250

Table 3. Continued

Ex. 3: Integrated Cooling Module			
A skid mounted container, that includes the absorption chiller, cooling tower, pumps, genset interface, and controls interface. Near-term emphasis is on cost reduction and maintainability through component standardization and factory packaging. Mid-term emphasis also includes absorber performance improvements.			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
Size (tons)	100	100	100
Module Cost ($/ton)	1,000	700	500
Absorber COP	0.6	0.65	0.8
Heat input Temp (^{o}F)	210	230	250

Ex. 4: Engine Heat Optimized Absorber			
Single-effect absorption chiller optimized for medium temperature heat from a natural gas engine. Near-term goals are directed at optimizing absorber sub-systems for engine quality heat. Mid-term activities stresses absorber performance improvements and higher quality engine heat.			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
Size (tons)	100	100	100
Absorber Cost ($/ton)	400	250	200
Absorber COP	0.6	0.65	0.8
Heat input Temp (^{o}F)	210	230	250
Foot-print (ft^2)	84	55	45

Table 3. Continued

Ex. 5: Supermarket CHP-Refrigeration/Subcooling Package			
Continuous CHP sized electrically for minimum night-time load with absorption subcooling of the refrigeration system. Integrated systems to replace reclaim heat with CHP heat to further optimize refrigeration efficiency.			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
CHP Size (kW)	75-250	75-250	75-250
Chiller Size (tons)	20-90	20-90	20-90
Chiller Cost $/ton	$2,000	$1,200	$750
Chiller COP (on thermal input)	0.7	1	1.2
Maintenance ($/kWh)	$0.02	$0.02	$0.01
Integration	Separate	Integrated Module	Integrated System
Controls	Custom	Standard	Standard
Installed System Cost ($/kW)	$2,800	$1,800	$1,200
Overall Efficiency (HHV)	60%	65%	75%

Ex. 6: CHP Benchmarking			
For specific application(s), develop standardized design methodologies to reduce site-specific engineering, permitting, procurement and maintenance costs; and to increase system reliability. Proposals addressing system sizes of 500 kW to 2 MW are envisioned. However, performance parameters and targets need to be adjusted to fit the size			
Parameter	**Baseline**	**Near Term 2005**	**Mid Term 2007**
size (kW)	500	500	500
Absorber size (tons)	100	110	130
Absorber COP*	0.6	0.65	0.8
Installed Cost ($/kW)	2000	1500	1200
Emissions (CARB)	2003	2003	2007
Package Efficiency (HHV)	70%	75%	80%
Maintenance ($/kWh)	0.015	0.012	0.010
Availability	92%	94%	96%

* Example absorber COPs are for reciprocating engine-based systems. A turbine-based system should have higher COPs.

C. Typical Proposals Requirements

Along with meeting the targets set forth above, a proposal for the upcoming CHP solicitation will generally also have to meet the following requirements:

- Target specific market/application segments – specify new, retrofit or both - and explain how this market/application is particularly suited for California.
- Discuss prior CHP experience in identified market sector(s) and factors impeding further deployment
- Describe proposed technology advancement and how it will help overcome current market obstacles
- List specific project goals with reference to existing baseline levels; should acknowledge California Air Resources Board Emission Requirements
- Describe linkage to relevant ongoing development work
- List sources of co-funding
- Teaming encouraged to fully address technical, financial, market, and business aspects of a successful development and commercialization proposal.
- If appropriate, applicants may include an upfront task to more thoroughly assess target market and goals.

IV. QUESTIONS FOR DISCUSSION

Listed below are initial questions to be discussed at the workshops and for response through e-mail. Please feel free to raise other issues relevant to the CHP targets for the upcoming solicitation.

1. What are the appropriate CHP system boundaries? (electric power, thermal recovery system, thermal utilization technology, controls and application interface)
2. How should CHP systems be grouped for evaluation purposes?
   by prime mover technology? (turbines, reciprocating engines, microturbines, fuel cells, other prime movers)
   by electric output size? (0-500 kW, 500-2,000 kW, 2-5 MW, 5-30 MW, >30 MW)
   by application? (industrial, commercial, by individual sector such as schools, supermarkets, food industry)
   by thermal application? (steam, hot water, cooling, dehumidification, refrigeration, direct process air)
3. Within the ranges defined (#2) what is the most appropriate focus and emphasis for the Commission's program?
4. What are the appropriate targets and stretch goals for system attributes?
   power generation efficiency?
   CHP system efficiency? (how best to define this – the highest efficiency is not always focused on the highest value applications, e.g., low temperature hot water vs. a more valuable higher temperature application)
   Package cost and capability? (including prime mover, generator, emissions controls, heat recovery, and system controls package)

Installation cost reduction? (engineering, onsite plumbing and electrical work, additional controls required, buildings and enclosures, other installation costs)
Maintenance cost reductions?
Reliability improvements?
Cost and performance for thermally activated technologies?

5. As currently defined, do the targets and stretch goals appropriately reflect the technically feasible horizon for the range of important applications in California?
6. How can we make the targets more complementary to other CHP research efforts (i.e. DOE)?
7. Are relevant project examples left out, and if so, what parameters and targets are associated with them?